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ABSTRACT

The paper discusses an experiment in which regression analysis was used to examine predictors of information retention following a college economics course. It was hypothesized that students taught in small classes with self-instructional materials would place a higher value on basic economic concepts and retain these concepts longer than students in large, traditional classes. Variables included class size, method of instruction, pre- and posttest scores, grade in the course, class, sex, SAT scores, and student attitudes towards economics. All students were tested over four years. New models were developed to solve problems of allocating correct explanatory power to each variable to correct shortcomings of existing retention models. Findings indicated a significant positive attitude change toward economics in smaller classes. It was concluded that, in spite of positive attitudes toward economics in small classes, cognitive performance remains comparable in small and large classes. Additional research and analysis is suggested.
(Author/DB)

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LARGE CLASS RETENTION:

THE EFFECTS OF METHOD IN MACROECONOMICS

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This paper uses regression analysis to examine one essential question: "What are the significant predictors of retention performance two years following an introductory economics class?" Some of the variables which are examined include class size, method of instruction, cognitive levels of learning, pre and post test scores[1], grade in the course, class, sex, SAT scores, and selected attitude questions that were statistically significant when students were taking the course. The paper examines the results using both one and two stage least squares methods of analyses, and also compares the differences in results when the achievement is defined as test score gain rather than closing the "gap" of possible performance.[2]

The total experiment was run over a period of four years, testing both self-instructional and traditional materials in large (N=250) and smaller (N=40 to 75) classes. Students in both class settings were encouraged to enlarge their understanding and appreciation of economics beyond the context of the course by doing some outside classroom projects.

One Stage Results for Large and Small Classes

We began our data analysis by determining which variables were significant in predicting retention test scores. Naturally one of the most important predictors was whether or not the students had taken additional economics

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[1] The pre, post, and retention test was the Test of Understanding in College Economics, Form A, Joint Council on Economic Education, 1968.

[2] The "gap" will consider two variations:

$$\frac{\text{Retention score - pre-test score}}{\text{Maximum score(33) - pre-test score}} \text{ and } \frac{\text{Retention score - post-test score}}{\text{Maximum score(33) - post-test score}}$$

The purpose of using this model is to eliminate the ceiling effect on students who achieve very high scores.

courses. (See equation on Table II.)

Table I divides the large classes into two cohorts, those who had only the introductory economics, and those who had taken additional economics courses. Those students with more economics courses had average retention test results which were 16 percentage points higher than those without additional courses, and our model predicted 81% of the variation in test score results for this group. This compares with a prediction of 53% for the group with only the introductory course. In the cohort without additional economics, the significant independent variables were the post-test score, the SAT verbal score, and a variable defined as the extent to which the students read contemporary economics in the newspapers. The only significant independent variable in the cohort with additional economics courses was the post-test score, which alone predicted 57% of the retention test result. The results in Table I have been ordered by significance levels as measured by the t-statistics, from the most to the least significant variable in each cohort. Of additional interest in this table is the result (which is consistent throughout the remainder of the paper) that the student's year is a negative predictor of performance, i.e. that the juniors who were freshmen during the course, outperformed the seniors (who had been sophomores).

When comparing these overall results with those from the smaller classes, we found that more of the independent variables were significant predictors in the smaller classes, particularly the attitude variable, the TUCE gain, the post-TUCE score, and the SAT scores. The retention TUCE mean scores were nearly identical to those from the larger sections. In these smaller classes there had been a significant and large positive attitude change towards economics during the formal course. There was little such change in the larger classes. In the small classes this attitudinal improvement was a significant

explanatory variable for the retention TUCE scores. As we theorized earlier[3], this variable lost much of its significance in the large classes.

Two Stage Results for Large Classes

Following Soper's[4] suggestions for describing his similar model predicting TUCE performance, we respecified our model by substituting instrumental variables to account for the endogenous nature of some of our predictors in our equation. Table II uses the Farrar-Glauber technique to indicate the sources of the multicollinearity in the variables post-TUCE and TUCE gain, as can be seen in the F-statistics for post-TUCE of 20.35 and the F-statistics for TUCE gain of 13.40. These are found in the diagonal in Table II. The t-statistics in this table indicate that TUCE gain is significantly intercorrelated with SAT scores, class and post-TUCE. TUCE gain measures the difference between pre and post-TUCE scores.

We employed an instrumental variable, $\hat{z}_1$, which was the residual generated by regression pre-TUCE on SAT verbal, SAT math, and the class of the student. Having the last three variables in the original model took away some of the explanatory power of the pre-TUCE results. The $\hat{z}_1$ residual represented prior knowledge of economics except SAT scores and student's class (which together predict 35% of the variation in pre-TUCE scores for the students with only introductory economics, and 55% of the variation in pre-TUCE scores for students with more economics).

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[3] Craig, Eleanor D. and James B. O'Neill, "The Folly of Large Classes," paper presented at the American Economics Assoc. Meeting, December, 1975.

[4] Soper, John C., "Second Generation Research in Economic Education: Problems of Specification and Interdependence," Journal of Economic Education, Fall, 1976, (38-51).

TABLE I DEPENDENT VARIABLE: RETENTION TUCE PERFORMANCE IN LARGE CLASSES

	Introductory Economics Only[a]					Students with Additional Economics Courses[b]				
	COEF	t-Stat.	R^2adj	Mean	S.D.	COEF	t-Stat.	R^2adj	Mean	S.D.
Retention TUCE				46.53	13.40	Retention TUCE				
Independent Variables						Independent Variables				
Constant	4.49	0.35				Constant	-20.40	-1.12	62.28	15.4
SAT VER	0.06	2.62**		499.36	84.20	Post-TUCE	1.37	2.56**	.565	64.90	12.9
READ EC	-11.20	-2.05**	.215	.11	.31	Grade	7.12	1.40	.568	2.76	.7
Post-TUCE	0.40	2.03	.219	59.80	14.70	Method	-11.47	-1.30	.638	.43	.5
Class	- 7.38	-1.75	.390	.23	.40	TUCE Gain	- 0.70	-1.26	.710	26.76	9.0
Method/Instruction 0=traditional 1=self-instructional	- 5.13	-1.42	.398	.43	.50	SAT VER	-0.04	-1.02	.719	536.19	99.1
						SAT MATH	0.04	0.98	.721	579.52	82.5
Attitude	- 1.07	-1.18	.444	5.43	2.00	Attitude	- 0.67	-0.50	.707	5.00	2.0
SAT MATH	- 0.009	-0.36	.452	546.17	88.10	Read EC	- 1.22	-0.23	.684	.38	.49
Grade in Course	0.67	0.26	.439	2.27	.80	Class	-0.88	-0.06	.656	.05	.21
Tuce Gain (during formal course)	0.01	0.07	.426	27.02	14.20						
		R^2=.526						R^2=.811			

**Significant beyond .01 level

[a] df = 46

[b] df = 20

The second instrumental variable developed was $\hat{z}_2$ which served as a proxy for the "efficiency with which the student employed his stock of human capital in the course itself."[5] We regressed post-TUCE on SAT verbal, SAT math, student's class and student's interest in reading economics. The $\hat{z}_2$ residual represented learning in the course independent of those other variables, which had accounted for 19% of the variation in post-TUCE scores for the students taking only introductory economics, and 38% of the variation in post-TUCE scores for those students taking more economics.

The significance of the respecified equation is the attempt to allocate the correct explanatory power to each of the independent variables in the equation. Table III compares the one stage and two stage results in terms of both the regression coefficients and the t-statistics. The two stage model increased the regression coefficients and increased the significance of several of the variables, particularly the SAT math scores and the class. However, one variable (reading economics) which had been significant for the cohort without more economics in the one stage model, lost its statistical significance in the two stage model.

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[5] Ibid, p. 45.

TABLE II: FARRAR-GLAUBER TRANSFORMATION MATRIX FOR ENTIRE SAMPLE

	ATTITUDE	TUCE GAIN	READ EC	METHOD	GRADE	MORE EC	CLASS	SATMATH	SATVER	POST-TUCE
POST-TUCE	-0.20	8.72**	-0.21	1.15	2.05*	0.33	-1.61	2.22*	2.45**	20.35**
SATVER	1.58	-2.85**	-0.27	-0.56	1.19	0.26	0.15	3.20**	6.53**	
SATMAT	-0.52	-1.34	0.36	-1.28	1.07	0.09	1.16	6.98**		
CLASS	-0.32	1.76*	-0.32	-1.48	1.09	-1.81*	1.65			
MORE EC	0.10	-0.89	2.55**	0.34	1.74	2.13*				
GRADE	-2.03*	0.41	-0.50	-0.005	6.21**					
METHOD	1.26	0.16	-1.46	1.81						
READ EC	-1.28	1.09	1.59							
TUCE GAIN	0.99	13.40**								
ATTITUDE	1.49									

* indicates significance at .05 level.
** indicates significance at .01 level.

Diagonal elements are f-statistics with 58 and 8 d.f.
Off-diagonal elements are t-tests with 58 d.f.

Retention TUCE = -1.77 + .002 SATmath + .017 SATverbal* + .180 Post-TUCE* - .028 TUCE Gain + 3.54 More Ec*
(3.29) (.006) (.006) (.057) (.057) (1.02)

+ 2.41 Grade - 1.37 Read Ec - 1.26 Method - 1.98 Class - 0.22 Attitude.
(1.62) (1.19) (0.96) (1.22) (0.22)

TABLE III: REGRESSION COEFFICIENTS AND t-STATISTICS FOR SINGLE EQUATION AND MULTIEQUATION MODELS

	INTRODUCTORY ECONOMICS ONLY				STUDENTS WITH ADDITIONAL ECONOMICS COURSES			
	One Stage L.S.		Two Stage L.S.		One Stage L.S.		Two Stage L.S.	
	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Constant	4.49	0.35	12.11	0.97	-20.40	-1.12	-13.23	-0.68
Grade	0.67	0.25	0.67	0.26	7.12	2.56**	7.12	1.40
Method	-5.13	-1.42	-5.13	-1.42	-11.47	1.40	-11.47	-1.30
SAT Verbal	0.06	2.62**	0.07	3.04**	-0.04	-1.30	0.02	0.47
SAT Math	-0.01	-0.36	0.02	0.74	0.04	-1.26	0.09	2.45**
Attitude	-1.07	-1.18	-1.07	-1.18	-0.67	-1.02	-0.67	-0.50
Read Ec	-11.20	-2.05**	-0.22	-1.73	-1.22	0.98	-2.84	-0.51
Class	-7.38	-1.75	-8.24	-2.06**	-0.88	-0.50	5.58	0.38
Post TUCE	0.40	2.03**			1.37	-0.23		
TUCE Gain	0.01	0.07			-0.70	-0.06		
$\hat{z}_1$			-0.01	-0.07			0.70	1.26
$\hat{z}_2$			0.42	3.01**			0.66	1.86
	R^2=.526				R^2=.811			

**significant at the .01 level.

PreTUCE = -11.41 + .051SATVER** + .036SATMAT - 6.33CLASS
(9.47) (.018) (.018) (3.3)

R^2=.352 Adj R^2=.307

PostTUCE = 17.78 + .065SATMAT +.012SATVER -2.23CLASS +4.71ReadEc
(14.69) (.029) (.009) (5.16) (6.70)

R^2=.189 Adj R^2=.011

Pre-TUCE=.872 +.035SATVER +.032SATMAT -.60CLASS
(10.02)(.018) (.022) (6.53)
R^2=.550 Adj R^2=.471

PostTUCE=9.80 +.041SATMAT +.059SATVER +9.86CLASS
(20.56)(.047) (.037) (14.16)

- 2.42 ReadEc R^2=.378 Adj R^2=.223
(5.60)

Using the Farrar-Glauber technique after having corrected for multicollinearity by the 2SLS, we found that the new $\hat{z}_1$ and $\hat{z}_2$ variables had far lower F statistics than earlier, indicating that we had eliminated much of the multicollinearity by using the instrumental variables. The $\hat{z}_2$ variable was no longer significant--this is the predictable result.

The presence of multicollinearity can also be detected by examination of a pair-wise correlations table. This is shown with a model which includes grade in course and predicted grade point average, as well as the variables previously mentioned. The predictive capability of this new model was approximately the same as the previously used model; however, more of the independent variables were significant. These variables included the predicted grade point average, SAT scores, post-TUCE scores, and whether the students had taken additional economics courses. We used this new model with both the one-stage and the two-stage model and found the results to be similar to our other model.

TABLE IV: TRANSFORMATION MATRIX FOR ENTIRE SAMPLE USING 2SLS

	ATTITUDE	$\hat{z}_1$	READ EC	METHOD	GRADE	MORE EC	CLASS	SAT MATH	SAT VER	$\hat{z}_1$
$\hat{z}_2$	1.08	2.46*	0.61	1.92	3.84*	-0.76	0.01	-0.77	-0.74	3.37*
SATVER	1.45	0.07	-0.58	-0.33	1.72	0.51	-0.52	8.15*	4.99*	
SATMAT	-0.43	-0.05	1.18	-0.68	3.12*	0.08	0.96	6.03*		
CLASS	-0.14	0.11	-0.12	-1.61	0.98	-2.06*	1.21			
MORE EC	0.09	0.89	2.50*	0.34	1.74	2.13**				
GRADE	-2.02	-0.41	-0.23	-0.005	6.21*					
METHOD	1.26	-0.16	-1.31	1.81						
READ EC	-1.20	-0.91	1.43							
$\hat{z}_1$	-0.98	0.99								
ATTITUDE	1.49									

*significant at .01 level.

**significant at .05 level.

PRETES = -6.68 + .044SATVER* + .034SATMAT* - 5.59STUD.YR.** R^2=.40
(6.66) (.013) (.014) (2.61) R^2adj=.38

POST = 15.24 + .026SATVER** + .058SATMAT* - 2.02STUD.YR. + 2.28READEC
(10.78) (.018) (.023) (4.23) (4.07)
R^2=.23
R^2adj=.18

RAWSC = .679 + .063SATVER* + .032SATMAT + 1.49GRADE - 7.66STUD.YR.*
(9.91) (.018) (.020) (2.19) (3.62)

-3.01READEC - 0.55ATTIT - 3.77METHOD + 10.14MOREEC* + .090$\hat{z}_1$
(3.56) (.689) (2.89) (3.16) (.173)

+.419$\hat{z}_2$*
(.124)

R^2=.63
R^2adj=.57

TABLE V: PAIR-WISE CORRELATIONS

	RETEN TUCE	PREDGP	SATVER	SATMAT	GRADE IN COURSE	CLASS	READEC	ATTIT	METHOD	POST TUCE	MORE EC
RETEN TUCE	1.00	.33	.56	.49	.52	-1.15	.09	-.12	-006	.59	.46
PREDGP		1.00	.66	.73	.51	.24	.08	-.11	-.12	.38	.15
SATVER			1.00	.61	.42	.04	.01	.02	-.11	.38	.18
SATMAT				1.00	.49	.16	.10	-.14	-.20	.45	.17
GRADE IN COURSE					1.00	.13	.11	-.24	-.05	.58	.27
CLASS						1.00	-.03	-.10	-.24	.01	-.22
READ EC							1.00	-.21	-.19	.10	.32
ATTIT								1.00	.24	-.02	-.09
METHOD									1.00	.14	-.003
POST TUCE										1.00	.16
GAIN (RETEN. POST)											-.009
MORE EC											1.00

RETEN TUCE = -4.44 - 11.23PREDGP* + .069SATVER* + .030SATMAT + 2.35GRADE - 4.80CLASS - 3.85READEC
(9.61) (5.07) (.021) (.023) (2.15) (3.66) (3.47)

-.63ATTIT - 3.09METHOD + 0.42POST* - .008TUCEGAIN + 10.35MOREEC* R^2=.665 R^2adj=.599
(.668) (2.82) (.177) (.171) (3.06)

*significant at .01 level.

Method of Instruction

Examining retention performance, for students who had taken only the introductory courses, there was a three percentage point difference in cognitive performance between the traditional and the self-instructional means of study (see Table VI). This difference was consistent for all three levels of learning. In the large sections, the traditional textbook approach resulted in higher overall performance levels (5.2% points) and higher scores on the recognition and understanding questions as well as the simple and complex application questions.

TABLE VI

COGNITIVE LEVEL OF PERFORMANCE
(Students with Only Introductory Courses)

	Small Classes		Large Classes	
	Traditional	Self-Instruc.	Traditional	Self-Instruc.
Recognition and Understanding	18.0%	17.7%	17.1%	15.0%
Simple Application	16.5	15.5	14.9	13.8
Complex Application	8.4	12.9	14.6	12.6
Total Retention Score	42.9%	45.9%	46.6%	41.4%

Comparing method of instruction in the large classes with that of the small classes indicated that the retention test scores were higher under traditional learning methods in the larger classes, while self-instructional methods generated higher retention TUCE scores in the smaller classes. In discussing type of learning, it should be noted that in small classes,

performance on complex application questions was improved with the self-instructional method. This conclusion did not hold for the large sections.

Using the two-stage formulation to analyze means of instruction in the large classes verified our previous conclusion about using the two stage model for our data set. Some of the explanatory variables increased in significance, and others decreased. In both cases, our new variable $\hat{I}_2$ which measured the student's application of his human capital, was a significant predictor of the gap closed between the pre-test and the retention test.

TUCE Gap

Theory would suggest that the TUCE gain and the TUCE gap models might predict approximately the same percentage in the variability of the scores for the students with only the introductory economics course. (Our results confirmed this by predicting 53% of the retention scores in both cases.) This was because the scores of the students with only the Introductory courses, were lower and they thus were farther away from the ceiling. The TUCE gain model predicted 81% of the variability for the students with more economics, and the TUCE gap model predicted 94% of the variability for the same cohort. These students were performing closer to the maximum possible score. (See Table VII.)

Another gap we examined using the same methodology was that between the retention TUCE and the Post-TUCE tests. This analysis reduced the predictive capability of the model on students with more economics; and the same independent variables were statistically significant.

TABLE VII: COMPARISON OF SINGLE EQUATION AND MULTIEQUATION PREDICTIONS OF PRE-RETENTION TUCE USING GAP CLOSING MODEL

	INTRODUCTORY ECONOMICS ONLY				STUDENTS WITH ADDITIONAL ECONOMICS COURSES			
	One Stage L.S.		Two Stage L.S.		One Stage L.S.		Two Stage L.S.	
	Coef.	t-Stat.	Coef.	t-Stat.	Coef.	t-Stat.	Coef.	t-Stat.
Constant	- .001	- .0005	2.16	1.09	7.20	2.08*	3.42	1.86
SAT Verbal	.004	0.71	-0.12	-0.92	0.01	1.71	-0.42	-0.91
Read Ec	-0.75	-0.50	-2.12	-0.42	-1.69	-1.77	-1.26	-1.41
Class	-0.93	-0.87	-1.62	-1.69	-1.85	-2.28*	-2.31	-2.64**
Method	0.74	0.81	0.69	0.79	-0.16	-0.78	-0.41	-0.76
Attitude	-0.31	-1.35	-0.42	-1.61	0.10	0.15	0.21	0.41
SAT Math	.003	0.54	0.09	0.94	-0.02	-0.46	-0.01	-0.47
Grade	0.75	1.30	0.61	0.91	0.95	2.57**	1.01	2.92**
Post	0.50	5.90**			0.18	1.06		
$\hat{z}_1$ [a]			.002	0.42			.04	.062
$\hat{z}_2$ [b]			.86	11.21**			.061	2.01
			R^2=.614				R^2=.940	

*indicates significance at .05 level.
**indicates significance at .01 level.

[a] PreTUCE = 11.12 +.061SATVER +.002SATMAT -6.21CLASS
(9.61) (.094) (.04) (4.44)
R^2=.394

[b] PostTUCE = 4.61 -.002SATMAT +.04SATVER -4.21CLASS
(2.91) (.014) (.08) (2.22)
+ 3.62READEC
(1.94)
R^2=.246

[a] PreTUCE =-14.12 +.016SATVER +.012SATMAT -4.63CLASS
(10.61) (.042) (.061) (3.12)
R^2=.339

[b] PostTUCE = 26.14 -.014SATMAT -.062SATVER
(14.21) (.021) (.041)
- 14.62CLASS + 6.41READEC
(6.14) (4.31)
R^2=.216

We also used the two stage model to analyze the data with both of the gap definitions. In neither case did the new model add any appreciable predictive capability to our model. The comparative coefficients and t-statistics are summarized as Table VII for the gap closing model comparing the pre and retention test scores.

Conclusions and Implications

The implications of our retention findings with the large sections were less substantive than with an earlier retention test with smaller sections. As instructors, we have held strong convictions that students with positive attitudes towards economics will value and retain the basic concepts over time. In predicting retention performance, few variables proved statistically significant.

Our earlier findings (performance during class, change in attitudes, retention) with the small sections indicates student retention results were maximized when students are taught in small sections with self-instructional materials. However, the results in Table VI, where large traditional sections performed comparably or greater than small self-instructional sections will require further analysis by the authors.

Our retention results for large sections compared with class performance in the cognitive area are in conflict with data collected during the sequence of the course. Although we are experiencing a dilemma, our conclusions based on test performance, change in attitudes, and course/instructor evaluations still lead us to pesently conclude as summarized by an anonymous comment written by a student at the end of the retention test:

> I would have liked the class much better if it were a small group class. I find large group lecture-type classes impersonal to a degree and inhibiting in the sense of wanting to ask a question or make a comment.

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